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ABSTRACT

This booklet is about the disposal of high-level nuclear waste in the United States with a particular focus on Yucca Mountain, Nevada as a repository site. Intended for readers who do not have a technical background, the booklet discusses why scientists and engineers think high-level nuclear waste may be disposed of safely underground. An introduction describes why Yucca Mountain is being studied and provides basic information about those studies. The contents present the following information: (1) What is nuclear waste?; (2) what spent fuel is; (3) the legislation governing high-level nuclear waste disposal; (4) the federal program for collecting data on a potential repository site; (5) what scientists will study in regards to site selection of a repository; (6) the movement of water; (7) studying the movement of rock; (8) how the repository would affect quality of life; (9) the licensing process as governed by the U.S. Nuclear Regulatory Commission; (10) which experts review the Department of Energy (DOE) studies; (11) repository description; (12) description of the "life cycle" of spent fuel; (13) preparing waste for shipping; (14) what happens when the repository is full; (15) plans for radiation protection; (16) hazards of repository radiation; (17) factors that increase or decrease exposure to radiation; (18) radiation dose to nearby people; (19) Americans' average personal radiation exposure; (20) plans for safe transportation; (21) shipping nuclear waste by road, rail, or combination of the two; (22) state and local government involvement; (23) DOE and communication with the public; (24) challenges involved with a repository; and (25) answers to some frequently asked questions. (MCO)

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DOE's Yucca Mountain Studies

What
are
they?

Why are
they being
done?

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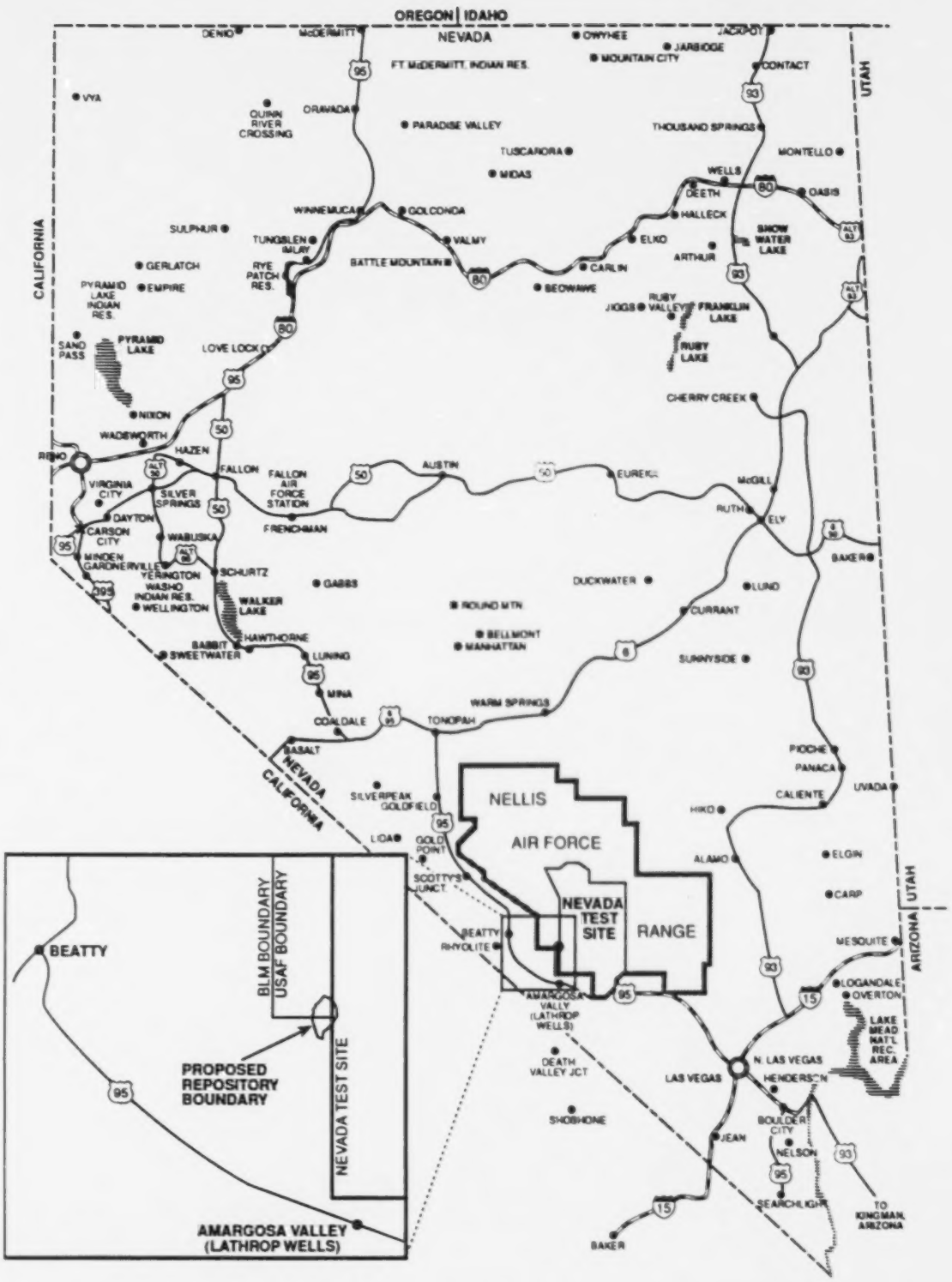
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Introduction

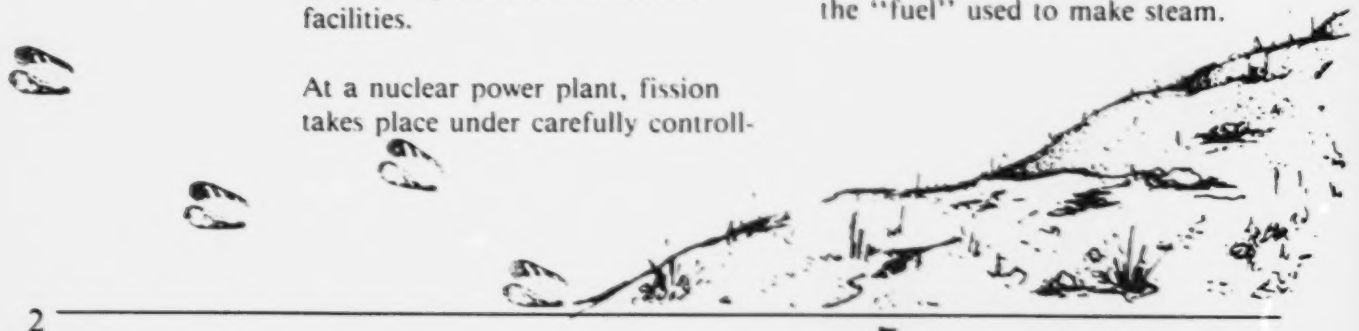
This booklet is about the disposal of high-level nuclear waste in the United States. It is intended for readers who do not have a technical background. It discusses why scientists and engineers think high-level nuclear waste may be disposed of safely underground. It also describes why Yucca Mountain, Nevada, is being studied and provides basic information about those studies.

The question of how safely to dispose of high-level nuclear waste has been a scientific and public concern since the beginning of the nuclear age. The first commercial nuclear power plant in the United States began operation in 1957. Since then, the United States has come to rely on nuclear energy as a significant source of electricity, second only to coal. Nuclear energy is used to make important contributions to medicine, research, and national security. But the benefits of nuclear power come coupled with great challenges. In this case, the challenge is the safe disposal of radioactive waste.

What is nuclear waste?

Nuclear, or radioactive, wastes result whenever we put nuclear fission to work. Nuclear fission occurs when atoms split and a "nuclear reaction" takes place. The energy from that nuclear reaction is used to make electricity. High-level radioactive, or nuclear, waste is the by-product of making electricity at commercial nuclear power plants and from production at defense facilities.

At a nuclear power plant, fission takes place under carefully controlled conditions inside the nuclear reactor. Nuclear fission generates energy, including heat. This heat is used to make steam, which turns turbines to make electricity. To understand how nuclear fuel is used to make electricity, think about other power plants. When electricity is made at coal-fired plants, coal is the fuel burned to make steam. At nuclear power plants, uranium is the "fuel" used to make steam.



What is "spent fuel"?

Approximately once a year, one-third of the nuclear fuel inside a reactor is removed and replaced with fresh fuel. The used fuel is called "spent fuel." It is highly radioactive and it is the primary form of high-level nuclear waste. It must be isolated carefully for thousands of years because its radioactivity has the potential to harm people and the environment. During that time, the spent fuel will decay to a level of radioactivity that is about the same as natural, uranium-ore deposits.

When spent fuel is removed from a reactor, it usually is put into a pool of water. The water serves as a radiation shield and coolant. Storing the spent fuel in pools is intended only as a temporary measure until a permanent disposal place is found. At some nuclear power plants, pool storage is nearing capacity.

As an alternative to storing in pools, some spent fuel is being stored aboveground in concrete or steel containers called "dry casks." Like storage under water in pools, this approach also is intended as temporary.

Today, using pools and dry casks, approximately 20,000 metric tons of spent fuel is stored at more than 60 nuclear power plant locations across the country. By the year 2000, it is expected that there will be more than 40,000 metric tons of spent fuel. By then, from defense programs there also will be about 8,000 metric tons of high-level nuclear waste requiring disposal. Currently, defense high-level waste is stored primarily at three U.S. Department of Energy (DOE) facilities, one each in Idaho, South Carolina and the state of Washington.

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The legislation governing high-level nuclear waste disposal

The need to find safe, permanent disposal is becoming more and more critical. Because these decisions will affect present and future generations, Congress provided for various parts of society to be involved in the decisions. Scientists, concerned citizens, and members of Congress, industry, and government all may participate in this process. Their involvement underscores this project's commitment to protecting public health and safety.

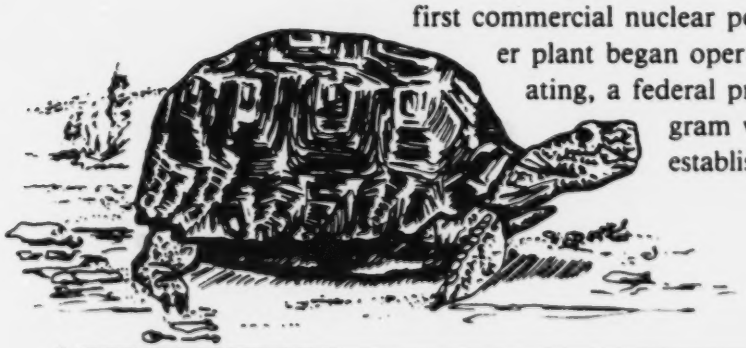
In 1982, Congress established a national policy to help solve the issue of high-level, nuclear waste disposal. This policy is in a federal law, the Nuclear Waste Policy Act. Congress based this policy on what most scientists agreed was the best way to dispose of nuclear waste.

The Nuclear Waste Policy Act made the U.S. Department of Energy (DOE) responsible for locating, building, and operating an underground disposal facility, called a geologic repository. Using a geologic repository dates back to 1957 when the National Academy of Sciences recommended that the best means of protecting the public health and safety and the environment, while the radioactivity decayed, would be to dispose of the waste in rock, deep underground. Scientists had studied many options, including burying it in the ocean floor, disposal within polar ice sheets, and rocketing it into outer space.

The Nuclear Waste Policy Act established a detailed schedule for DOE to follow. To pay for all of this, Congress established the Nuclear Waste Fund. People who use power from nuclear power plants pay for nuclear waste disposal through their utilities.

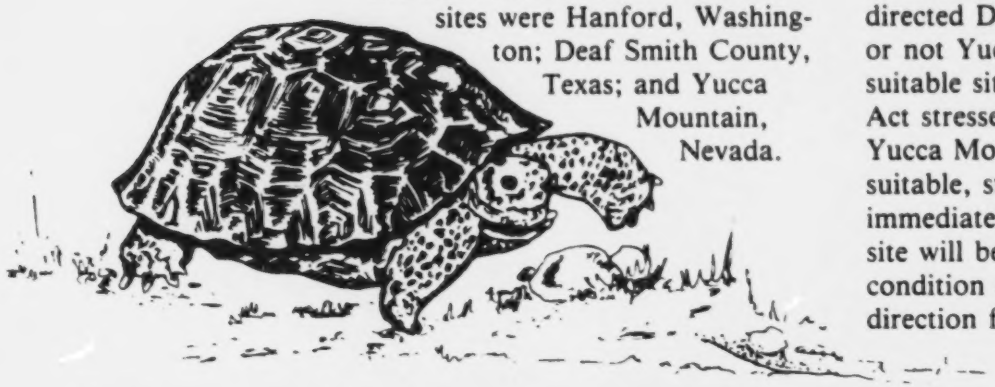
Federal program began in 1976

In 1976, nearly 20 years after the first commercial nuclear power plant began operating, a federal program was established to collect data on potential repository sites. The 1982 Act was based on what was learned during this earlier program. In 1983, DOE selected nine locations in six states for consideration as potential sites.



These sites were studied and results of these preliminary studies were reported in 1985.

Based on those reports, President Ronald Reagan approved three sites for intensive scientific study called "site characterization." The three sites were Hanford, Washington; Deaf Smith County, Texas; and Yucca Mountain, Nevada.



In December 1987, Congress amended the Nuclear Waste Policy Act and directed DOE to study only Yucca Mountain. This congressional action was criticized by many Nevadans, who felt the 1987 Amendments Act was unfair. In the Amendments Act, Congress directed DOE to determine whether or not Yucca Mountain is a suitable site for a repository. The Act stressed that if, at any time, Yucca Mountain is found unsuitable, studies will be stopped immediately. If that happens, the site will be restored to its natural condition and DOE will seek new direction from Congress.

What will scientists study?

Many scientists think that Yucca Mountain has features that may make it suitable for a nuclear waste repository; others do not. By "suitable," scientists mean the rock will keep the waste sufficiently isolated for 10,000 years so that the radioactive material will not harm the public.

Yucca Mountain's deep ground-water table and type of rock seem capable of isolating waste. Its remote location in the desert 161 kilometers (100 miles) northwest of Las Vegas is extremely dry and far from a large population center. However, many scientific and technical issues about Yucca Mountain must be resolved to see if Yucca Mountain is or is not a suitable site for a repository. These include:

- how much water there is in the rock above the deep ground-water table and how it moves through the rock;
- the effects volcanic activity might have on a repository in Yucca Mountain;
- how an earthquake might affect a repository and the ground-water table about 244-366 meters (800-1,200 feet) below the repository; and
- environmental issues.

In addition to studies related to Yucca Mountain's geologic and

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environmental suitability, a variety of social and economic questions about a repository's effect on the quality of life in nearby communities will be researched.

Ten years of study are planned at Yucca Mountain to collect and analyze detailed environmental and geologic data from aboveground and underground. There also will be reviews by independent technical groups, and by the state of Nevada, as well as intense public scrutiny. Hundreds of scientists, engineers, and other experts will be involved; many scientific issues and opinions will be considered.

Various methods will be used to get information. These will include:

- laboratory studies;
- drilling holes to understand the geology (a science that deals with the history of the Earth as recorded in rock) and geohydrology (a science that deals with the quantity, quality, and movement of underground water);
- digging trenches to study faults ("cracks" in the Earth's crust accompanied by movement of one side of the crack in relation to the other); and
- other geophysical methods studying the potential for earthquakes (seismology), the potential for volcanoes (volcanology), the Earth's magnetic field, the area's background radioactivity, movement of the Earth's surface, and so on.

Scientists also will monitor the air, weather, soil, and water. All of these studies will be done to make certain the public and the environment are protected. Since these studies are so important, they are described in detail in the following paragraphs so readers may more fully understand them.

Studying the movement of water

Geohydrology studies will focus on how water moves through Yucca Mountain and how it could affect a repository. Yucca Mountain is in the southern part of the Great Basin where there is very little rainfall, most of which evaporates. Approximately 15.24 centimeters (six inches) of rain falls on Yucca Mountain in a year. Many scientists believe that only an extremely small fraction of that rain actually would reach the underground area where the proposed repository would be located.

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Additionally, the water table under Yucca Mountain is extremely deep. This makes it possible to put a repository about 305 meters (1,000 feet) underground and have it be about 244 meters (800 feet) above the water table. This is an area geologists call the "unsaturated zone," where there is relatively little water in the rock and in which water may move very slowly. These factors significantly limit the chance of water corroding the waste containers and carrying radioactive material away from a repository.

Studying the movement of rock

Seismic studies planned for Yucca Mountain will provide information about the potential for earthquakes or faults (cracks and movement of the rock). These will be done to ensure that facilities on the surface and underground would not be disturbed or disrupted. At present, it appears that risk of damage to underground facilities from earthquakes is very small. That is because the movement of local faults is small, with possibly many thousands of years between movements.

Experience with earthquakes throughout the world has shown that underground structures can withstand the ground motion generated by earthquakes. Additionally, tests involving nuclear explosions underground at the Nevada Test Site have shown that underground structures can withstand ground motion greater than that generated by earthquakes. On the surface, buildings can be engineered and built to withstand very strong ground motion.

Yucca Mountain is made up of layers of volcanic rock called "tuff." These layers were made approximately 11 million years ago in a volcanic eruption about 32 kilometers (20 miles) from Yucca Mountain. At that time, the forces of the gases underground were released, spewing gaseous foam up into the air, and then which fell to the earth in the form of ash. Still heated, this ash welded together and became compressed by its own weight. The volcanic tuff is at least 1.8 kilometers (6,000 feet) thick.

Some people wonder if faults and earthquakes could cause Yucca Mountain to break apart and expose buried radioactive waste. Most scientists believe this is impossible. This belief is based on strong evidence that Yucca Mountain has existed in about its present form for at least a few million years, during which time many earthquakes have occurred. Preliminary studies indicate that Yucca Mountain will remain stable for the period of time the waste must be isolated.

How would the repository affect our quality of life?

Studies already are being done and more are planned on environmental, socioeconomic, and transportation issues. Environmental studies focus on land use, water and air quality, potential impacts on plants and animals, and archaeological, cultural, historical, and Native American resources.

Socioeconomic studies include estimates of the repository program's effect on employment, including jobs with the program and jobs supporting the work of people in the program. Potential effects on community services, tourism, population distribution, social conditions, and government structure also are being studied.

Transportation studies evaluate shipping methods and routes. They also will cover technical and financial assistance to public safety organizations for emergency response training, if a repository were to be built at Yucca Mountain.

This wide array of studies will provide a credible basis for scientific decisions about the suitability of the site. It should be emphasized that if, at any time, these studies show that Yucca Mountain does not qualify as a repository site, DOE must stop work and report to Congress.

The licensing process is governed by an independent federal agency, the NRC

Licensing a nuclear waste repository means a thorough review of the DOE's scientific studies to ensure the safety of the facility and its operation. The U.S. Nuclear Regulatory Commission (NRC) is the federal agency responsible for licensing a proposed repository.

DOE continually reports to the NRC about its studies. At the end of these studies, DOE will prepare an Environmental Impact Statement to describe the potential effect a repository might have on the region surrounding Yucca Mountain. A copy of this statement will be put in public libraries and given to anyone who wants it. Additionally, public hearings on the statement will be held in Nevada.

If the studies indicate that Yucca

Mountain is a safe location for a repository, the Secretary of Energy will recommend to the president that a repository be built. If the site receives presidential approval, DOE will seek a license from the NRC to begin construction. According to federal law, the state of Nevada will have an opportunity to submit a "notice of disapproval," in effect a veto, after the presidential decision. If that happened, work at Yucca Mountain could continue only if a majority vote in Congress overruled the state's veto.

The NRC review is a long process which is expected to take at least three years. The process provides a way for individuals and interested organizations to have input into the NRC review. Representatives of the state of Nevada and local governments affected by the program are included as official participants.

Repository construction could begin only after the NRC completed its review and if it approved the license application. Scientific studies will continue during construction to confirm that what was predicted about behavior of the rock underground was accurate. The results of those studies also will be submitted to the NRC. Further NRC approval would be required before repository operations actually could begin.

DOE's work is checked by other experts

The Yucca Mountain Site Characterization Project is one of the most closely reviewed programs ever undertaken by the federal government. DOE's studies are reviewed by many organizations including:

- Congress;
- the General Accounting Office;
- the Nuclear Regulatory Commission;
- the state of Nevada;
- the local governments in Nevada that are designated as "affected" by the program;
- the independent Nuclear Waste Technical Review Board appointed by the president;
- the National Academy of Sciences;
- the electric utilities; and
- an independent accounting firm.

What would a repository look like?

The proposed repository would look like a large mining complex. It would have two types of industrial facilities — a facility on the surface for handling and packaging nuclear waste, and a large mine about 305 meters (1,000 feet) underground.

Current plans call for the waste to be placed in sealed, metal alloy canisters placed vertically in the floor of underground tunnels for permanent disposal.

Many kinds of different facilities would be built on the surface. These would include roads, utilities, waste-handling facilities, fire and medical service facilities, administrative offices, repair shops, water and sewage treatment plants, warehouses, a machine shop, an electrical shop, and a security office. These facilities would cover approximately a 160-hectare (400-acre) area and would be surrounded by a 4.83-kilometer (three-mile) buffer zone.

Underground, about 560 hectares (1,400 acres) would be mined. The underground facilities would include the tunnels leading to the areas where the waste containers would be placed, and service areas near the shafts and ramps that provide access from the surface.

The proposed repository will be designed to contain the radioactive material and to minimize any radiation dose to people, animals, and the environment. This will be done by using layers of shielding, by sealing the containers, and eventually by filling the holes and drifts. This approach, using layers of man-made and natural barriers, is used throughout the plans for the repository.

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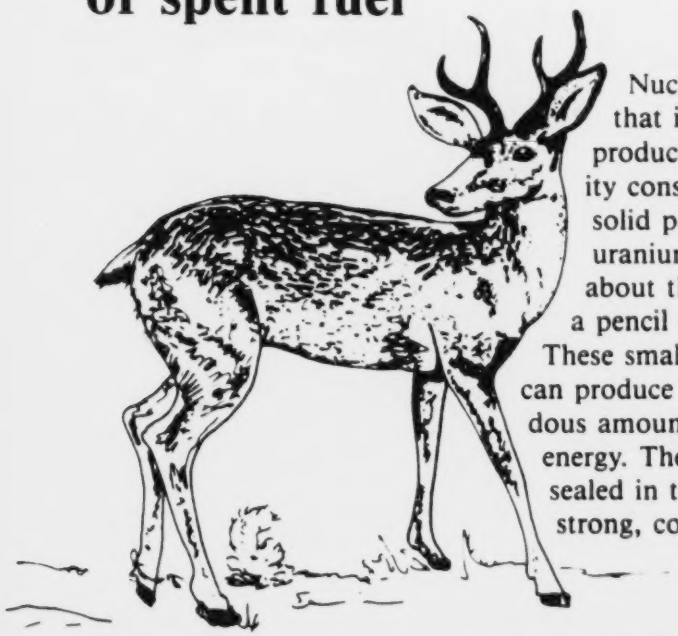
A simple description of the "life cycle" of spent fuel



Nuclear fuel that is used to produce electricity consists of solid pellets of uranium oxide about the size of a pencil eraser. These small pellets can produce a tremendous amount of energy. They are sealed in tubes of a strong, corrosion- and heat- resistant metal alloy. The tubes containing the uranium oxide pellets are bundled together to form a "fuel assembly." Many fuel assemblies are placed inside a nuclear reactor and used to generate heat to make electricity. The fuel will continue to provide that heat until the fuel is "spent," or no longer efficient in generating heat. At that point, it is removed and stored in a concrete, metal-lined pool of water, called a spent fuel pool or a cooling pool.

Preparing waste for shipping

From a cooling pool at a power plant, spent fuel would be packaged for shipment either to a temporary, central storage facility or to a repository. Spent fuel assemblies would be hoisted by remote control into strong, heavily shielded shipping containers. These containers are called casks and are designed to withstand severe accidents, should such accidents occur. The cask would then be closed, sealed, and inspected before being loaded onto a truck or railcar for shipment. Transportation casks used to ship radioactive waste must be certified by the Nuclear Regulatory Commission.

On arrival at the repository, the cask would be unloaded by remote control and carefully re-inspected. The fuel assemblies would be removed from the transportation cask and put into a canister, which would be welded shut. The waste canisters would then be taken by special vehicles down a ramp to rooms deep underground. There, by remote control, the waste would be placed inside the holes in the tunnel floors. After each canister is in place, a heavy shield will plug the hole, and the hole will be covered.

What happens when the repository is full?

After a repository has been filled to capacity, regulations require DOE to keep the facility open and to monitor it for a period of at least 50 years from the time fuel was first placed in it. This will allow experts to monitor conditions inside the repository while the radioactive waste is in place and also will allow the spent fuel to be retrieved if necessary or desired.

Eventually, the repository drifts and shafts will be filled with the rock and earth taken out of it and then sealed. At the ground level, facilities will be removed and, to the extent reasonable and feasible, DOE will take steps to return the site to its original condition.

What is planned for radiation protection?

Now that we have looked at how a repository would work, let's see how it would protect people. Federal government regulations that control high-level nuclear waste disposal direct that a repository should isolate waste until the radiation levels decrease naturally (a process called "decay") to a level that is about the same as that from a natural, underground, uranium-ore deposit. This decay time is about 10,000 years and this is reflected in the federal standards.

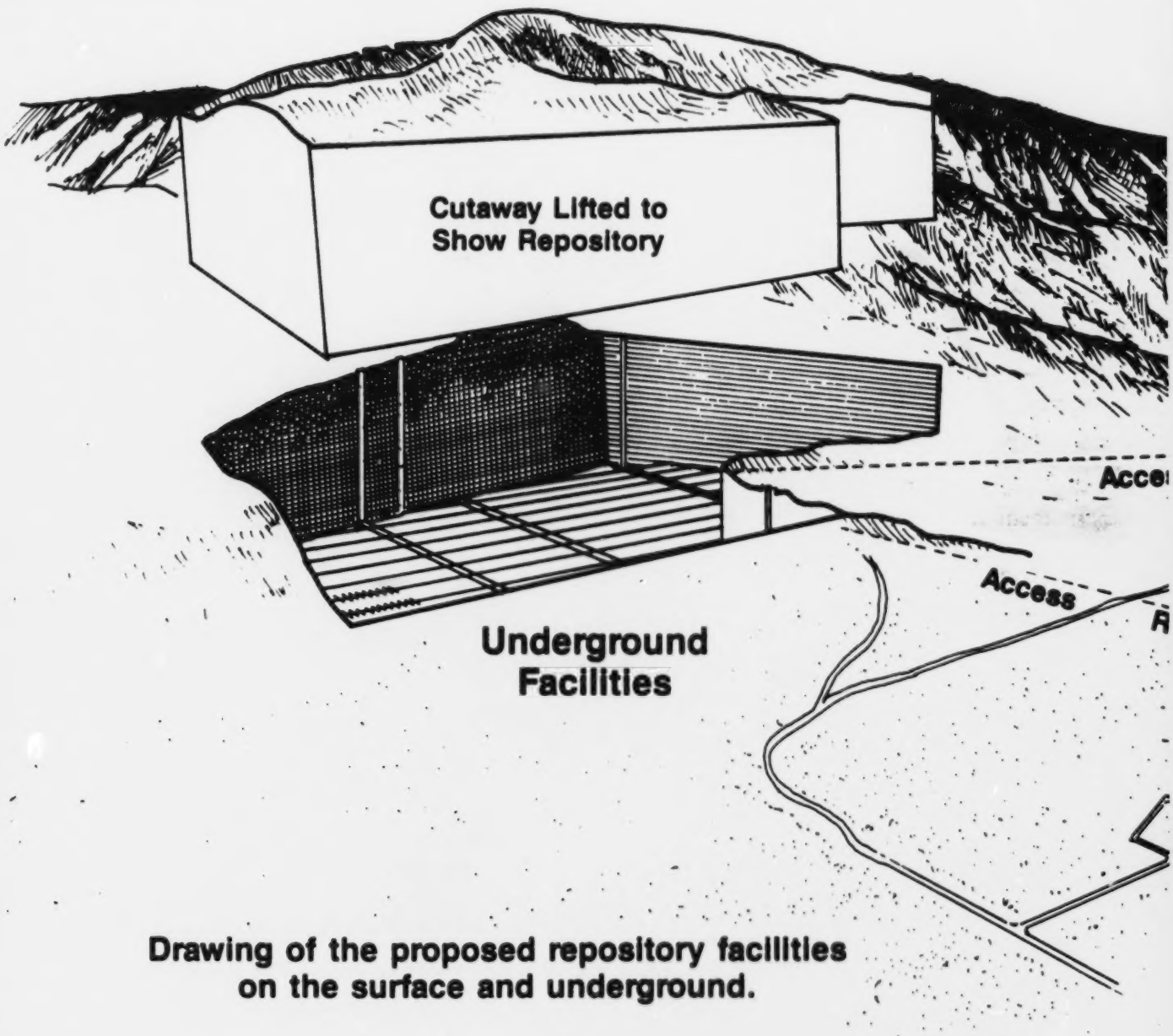
An underground repository is a safe disposal method because it will provide multiple layers of protection through natural and engineered barriers. Scientists and engineers assume that, over thousands of years, some of the man-made barriers in a repository will break down. Once that happens, natural barriers, the mountain itself, will be counted on to stop or slow the movement of radioactive particles. The most likely way for the particles to reach people and the environment would be by their movement in water. That is why the small amounts of water and being 244 meters (800 feet) above the water table are among important considerations for determining whether or not Yucca Mountain is a suitable location for a repository.

Many scientists believe that if the radioactive particles become dissolved in water in the rock above the water table, they would move very slowly. The radioactive particles also will have a distance to go before they would reach water used by people, plants and animals. By

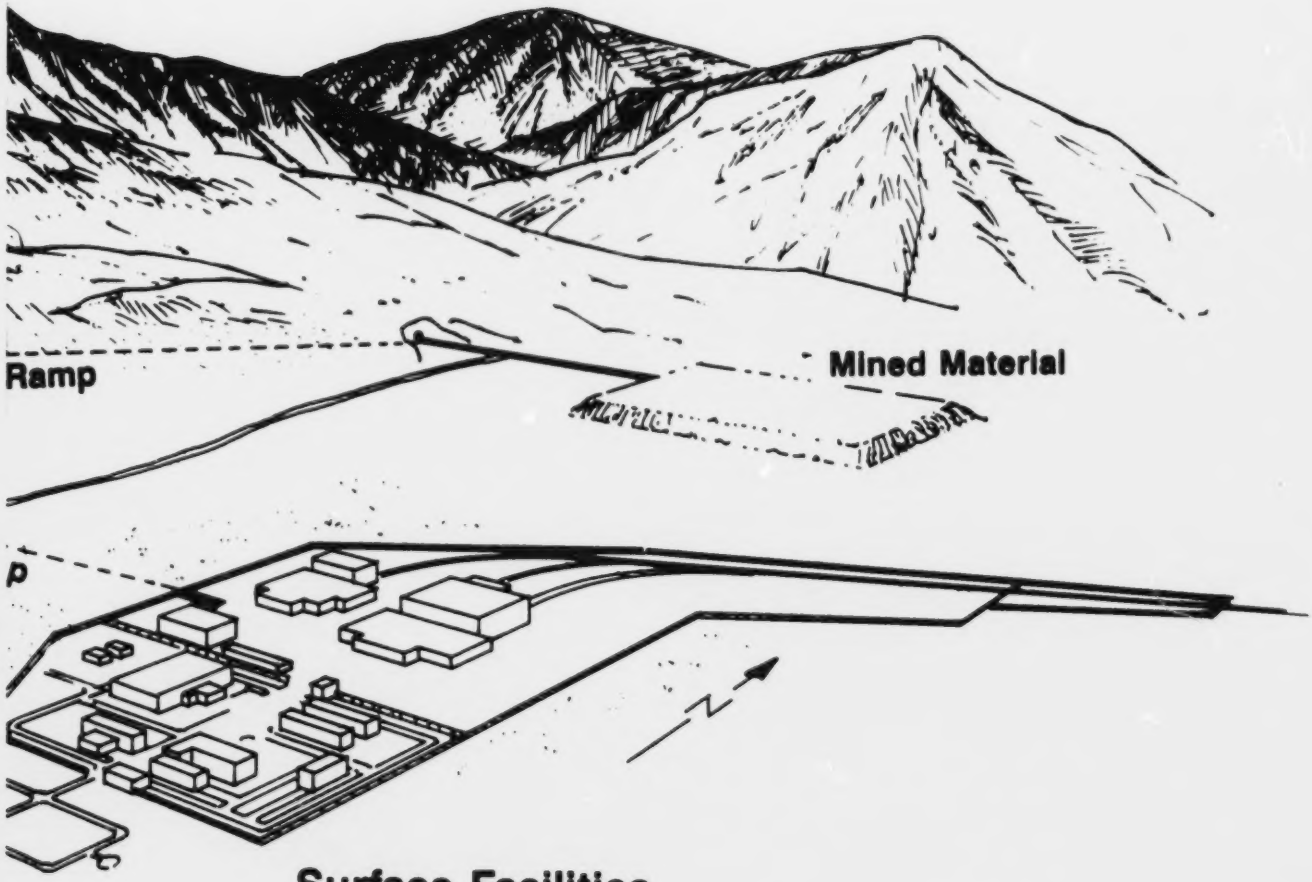
the time that happens, the radioactivity will have decayed to a level of radioactivity that could produce the same health effects as natural, underground, uranium-ore deposits. Studies designed to test these theories will be part of the evaluation of Yucca Mountain.

In addition, Yucca Mountain has chemical properties which act as another barrier to the movement of radioactive particles. Minerals in the rock called "zeolites" would stick to most particles of radioactive material. If radioactive particles were dissolved by the water in the rock, most scientists believe the zeolites would slow or greatly limit their movement to the environment.

To ensure that the underground waste would remain undisturbed, future generations will be alerted to the repository's location and significance through the use of large markers and permanent records in public libraries and information centers.



Drawing of the proposed repository facilities on the surface and underground.



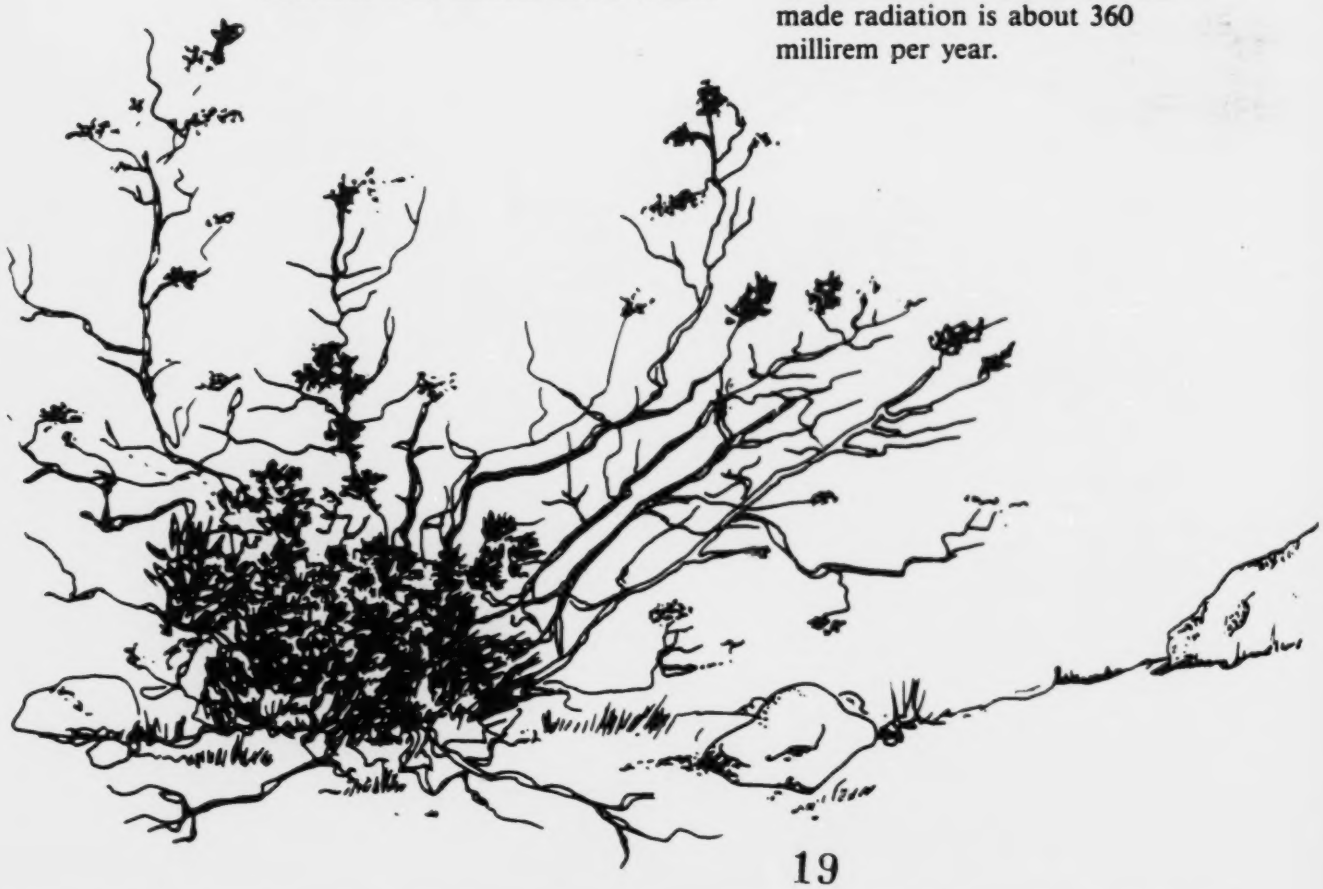
Surface Facilities

Understanding the hazards of radiation from a repository

We live with radiation every day. We receive radiation from cosmic rays from outer space and from radon gas and other naturally radioactive elements in the earth. This is called natural background radiation. It includes the radiation we receive from plants, animals, and from our own bodies.

We also are exposed to man-made sources of radiation, including medical and dental treatments, smoke detectors, microwave ovens, television sets, nuclear power plants, and emissions from coal-fired power plants.

Radiation is easy to detect with scientific instruments. The unit commonly used in the United States to measure radiation dose rate is the "millirem," which is one-thousandth of a "rem." A rem is a measure of the effect of a dose of radiation on human tissue. According to a 1987 study by the National Council on Radiation Protection and Measurements (NCRP), the average American's annual dose of natural and man-made radiation is about 360 millirem per year.



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Factors which increase or decrease exposure to radiation

A number of factors can vary the amounts of radiation dose we receive. Where we live affects the level of radiation to which we are exposed, since cosmic radiation levels increase with elevation. A person living in Denver, for example, receives 21 millirem of cosmic radiation dose per year compared to a person living in Chicago, who receives 2 millirem per year. This is because the earth's atmosphere is thinner at higher elevations and does not block as many incoming cosmic rays.

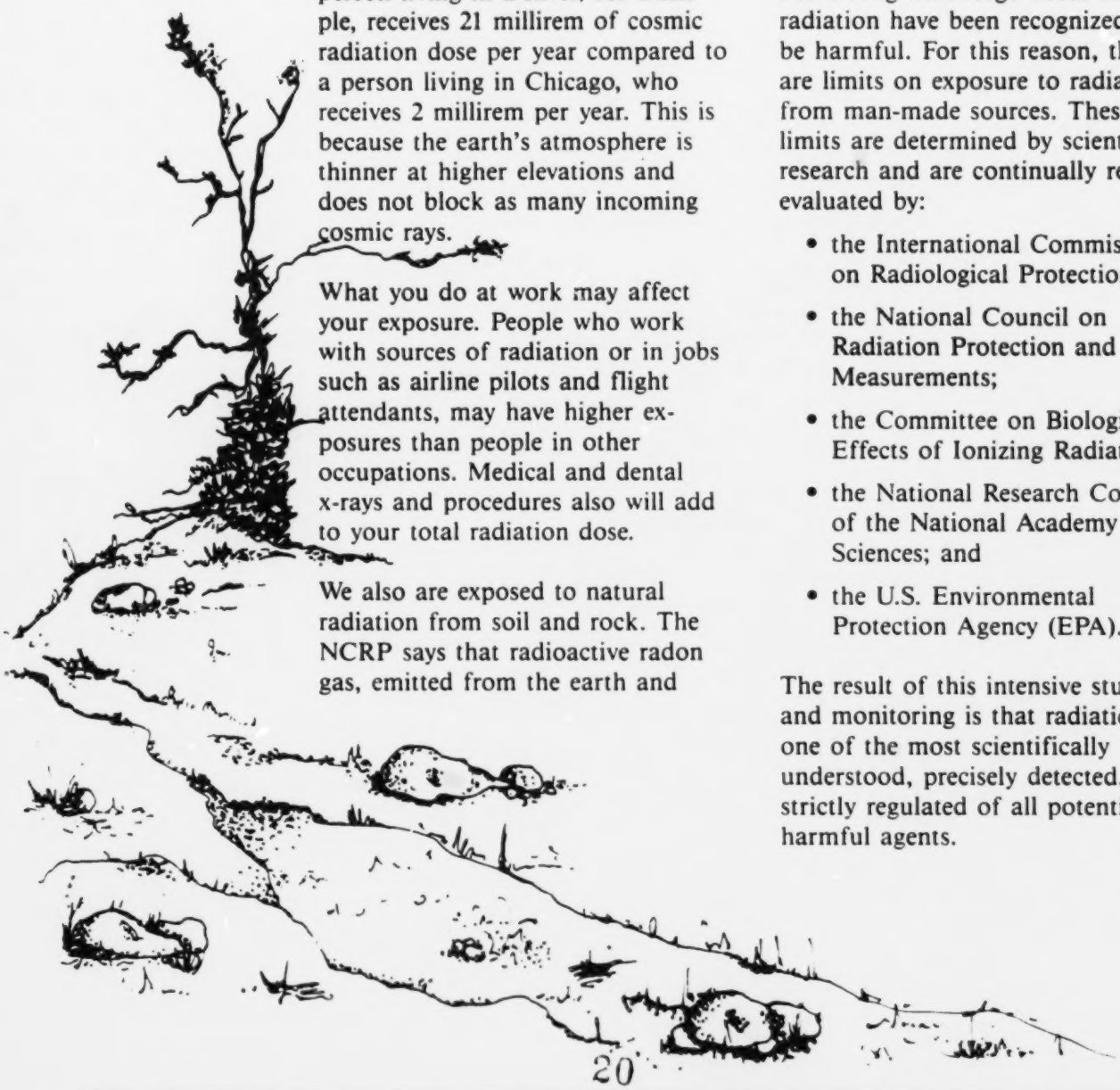
What you do at work may affect your exposure. People who work with sources of radiation or in jobs such as airline pilots and flight attendants, may have higher exposures than people in other occupations. Medical and dental x-rays and procedures also will add to your total radiation dose.

We also are exposed to natural radiation from soil and rock. The NCRP says that radioactive radon gas, emitted from the earth and trapped in tightly insulated homes with little ventilation, can account for up to 55 percent, or 200 millirem per year, of our annual exposure.

For a long time large doses of radiation have been recognized to be harmful. For this reason, there are limits on exposure to radiation from man-made sources. These limits are determined by scientific research and are continually re-evaluated by:

- the International Commission on Radiological Protection;
- the National Council on Radiation Protection and Measurements;
- the Committee on Biological Effects of Ionizing Radiation;
- the National Research Council of the National Academy of Sciences; and
- the U.S. Environmental Protection Agency (EPA).

The result of this intensive study and monitoring is that radiation is one of the most scientifically understood, precisely detected, and strictly regulated of all potentially harmful agents.



If a repository were built, would there be a radiation dose to nearby people?

Preliminary estimates indicate that if a person lived about 4.83 kilometers (three miles) from the proposed Yucca Mountain repository, less than 1 millirem of radiation per year would be added to that person's total background radiation exposure.

If a repository were constructed, the health and safety of repository workers and the public would be monitored continuously throughout the repository's construction, operations, and closing. Details of the monitoring program would be reviewed by the NRC as part of the licensing process. By law, the state and local governments, recognized as affected by the proposed repository, will have the right to review the results of the radiological monitoring process.

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Americans' average personal radiation exposure*

Radiation is all around us as a part of our natural environment. A commonly used measurement for it is millirem (abbreviated as mrem). Each year, the average dose per person from natural radiation sources is 360 mrem. To provide a context for this, background radiation in Las Vegas, Nevada is 51 mrem per year whereas background in Kerala, India is about 400 mrem per year.

It is not uncommon for any of us to receive far more than that in a given year because of trips we make, locations in which we live, medical procedures, or a variety of other factors. Some of those factors are illustrated in the chart which follows.

A person living 5 km from the proposed repository will receive less than 1 mrem per year as the result of proximity to the repository. No one is expected to live that close to the repository.

Examples of possible doses from common sources of radiation

Where you live		
Location: Las Vegas, Nevada** (Natural background)	51	mrem
Radon: (U.S. Average)	200	mrem
House Construction: For stone, concrete, or masonry building	7	mrem
What you eat, drink, breathe		
Food, Water, Air (U.S. Average)	24	mrem
World-wide weapons test fallout	4	mrem
How you live		
X-ray and radiopharmaceutical diagnosis		
One chest X-ray	10	mrem
Other examples are:		
Lower gastrointestinal tract X-ray is 500 mrem		
Radiopharmaceutical exam is 300 mrem		
Jet plane travel: For each 2,500 miles add 1 mrem	2	mrem
TV viewing: For each hour per day, .15; so 4 hours × .15	0.6	mrem
Sleeping: With partner, add 0.1 mrem	0.1	mrem
Cooking: With natural gas add 6 mrem	6	mrem
Total annual mrem dose for this example is	304.7	mrem
U.S. annual average dose is	**360**	**mrem**

Most scientists agree on the internationally recognized guidelines for regulating radiation doses to protect the public and the environment. By incorporating a philosophy that limits exposure to radiation to levels less than the limits stipulated by the regulations, doses are kept as low as reasonably achievable. This approach is used for members of the general public and the people who work around radioactive materials.

* NOTE: Doses are estimates only and vary at any given time.

** Based on the *Off-Site Environmental Monitoring Report: Radiation Monitoring Around United States Nuclear Testing Areas, calendar year 1988* - U.S. Environmental Protection Agency/Environmental Monitoring Systems Laboratory, Las Vegas, Nevada, 1989

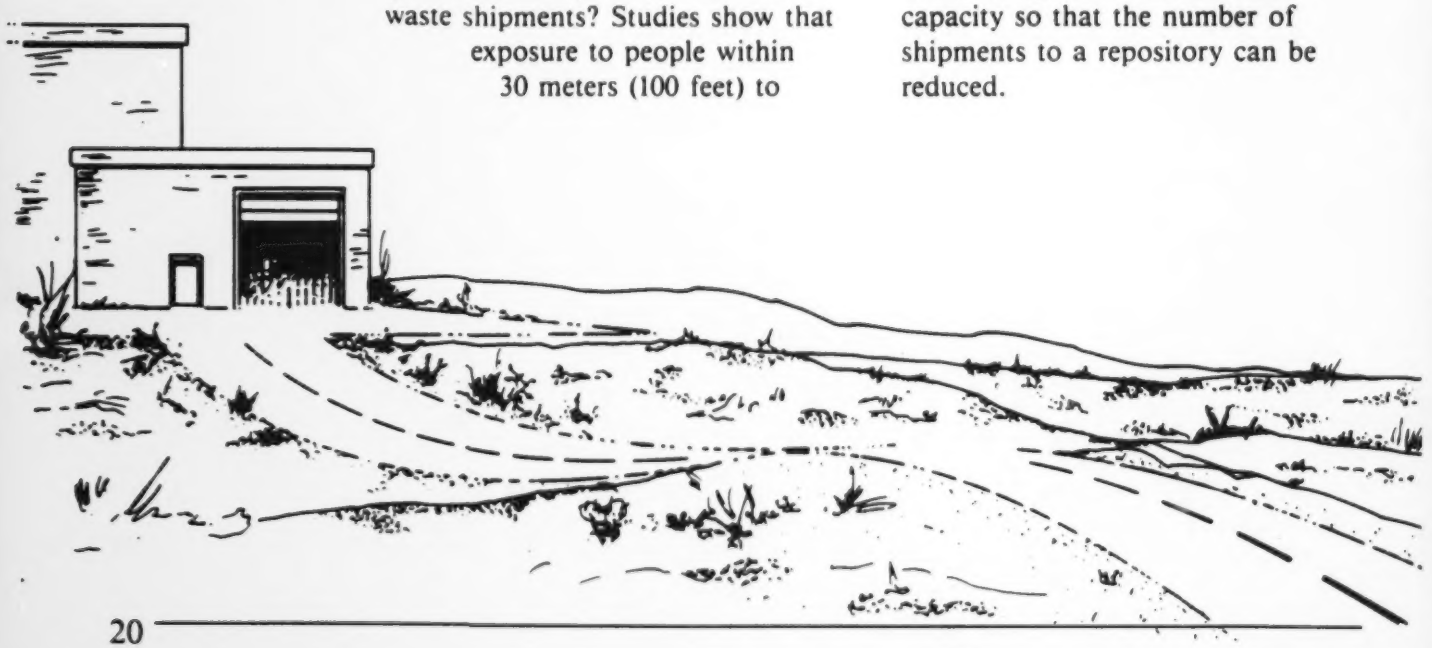
Plans for safe transportation built on an already-safe record

One of the major issues Nevadans and others voice questions about is transportation of spent fuel through their state. Their concern is the possibility of radiation exposure from a transportation accident. Most people are unaware that many kinds of radioactive materials are moved around our country each day. Shipments go to and from hospitals and medical research institutions, nuclear power plants, government research facilities, industrial complexes and other facilities. Despite all this transportation activity, the nuclear material safety record is excellent. In three decades, there has not been a single death or injury due to the radioactive nature of spent fuel during transportation.

What would be the radiation exposure from high-level radioactive waste shipments? Studies show that exposure to people within 30 meters (100 feet) to .85 kilometers (a half mile) from the route of a vehicle carrying high-level waste moving 24 kilometers (15 miles) per hour is one-thousandth to one-millionth of a millirem per shipment. This is an extremely small dose of radiation.

The cask in which nuclear waste will be shipped is the primary transportation safety feature. Shipping cask designs in use today go through rigorous crash and fire tests before being certified by the NRC to ensure that they will withstand accidents without a release of radiation.

The NRC will certify new casks which are being developed for the repository program. These new casks are not being developed because present cask design is unsafe or inadequate. New casks are being designed to increase cask capacity so that the number of shipments to a repository can be reduced.



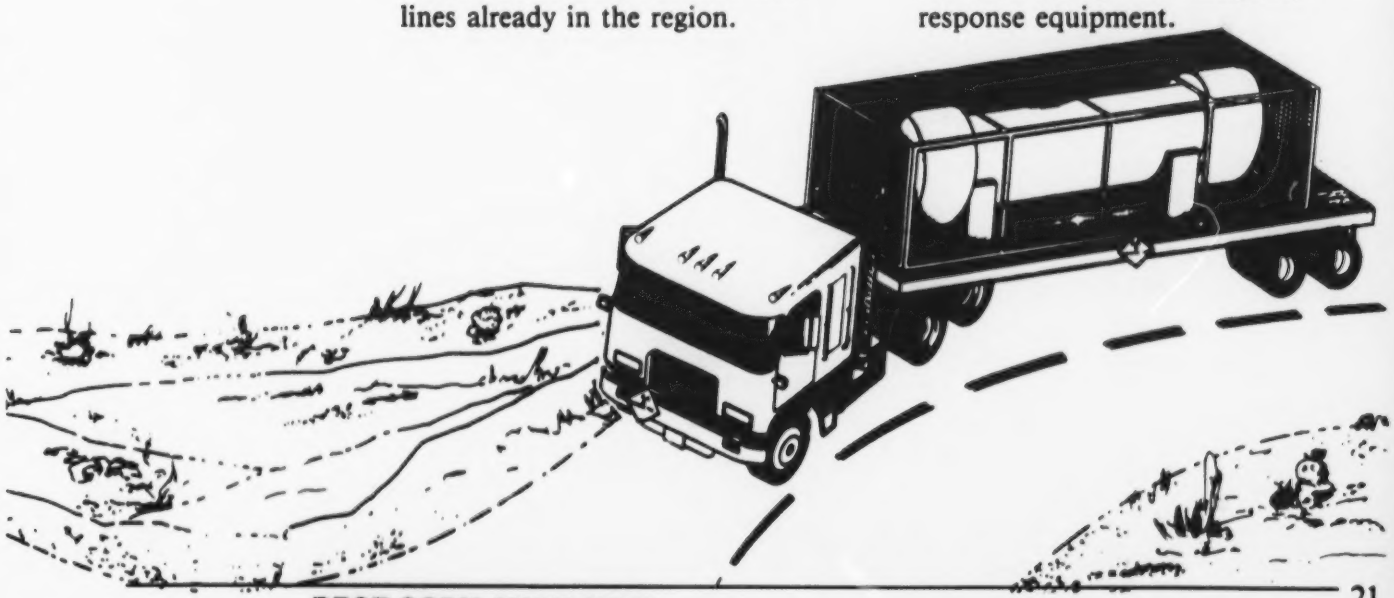
Ship by road? Ship by rail? Ship by a combinatio of the two?

The U.S. Department of Transportation (DOT) and the NRC regulate the shipment of nuclear materials. State and federal regulations control virtually every aspect of high-level waste transportation. Studies are being done to decide what method of shipment to a repository would be used. Is it best by rail or road, or a combination of the two?

DOE is studying possible routes for shipments of nuclear waste to Yucca Mountain if it should be determined suitable for a repository. Highway routes within the state will be selected from interstate highways or alternate routes named by the state in compliance with DOT regulations. Rail routes also will be selected according to federal regulations in effect at the time of shipment. To ship by rail, a rail spur would have to be built to connect Yucca Mountain with main rail lines already in the region.

According to current projections, nuclear waste shipments could begin by 2010. It should be noted that shipments of high-level radioactive waste to Yucca Mountain would begin ONLY IF the Yucca Mountain site is licensed by the NRC to receive waste. The approximate number of shipments to a repository each year is estimated to be 250 by rail and 1,000 by truck.

If nuclear waste shipments to Yucca Mountain begin, extensive safety checks will play an important role. Inspections will be made by drivers and state inspectors before the shipment leaves, en route, and when the shipment arrives at its destination. Before a repository could open, highway patrol officers, firefighters, emergency medical personnel, and other public safety workers will receive training and emergency response equipment.



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State and local governments have a say in the process, by law

The Nuclear Waste Policy Act and Amendments specify that funds be provided to the state of Nevada and some local governments for independent studies and review of the program. DOE interacts formally and informally with state and local agencies and various groups.

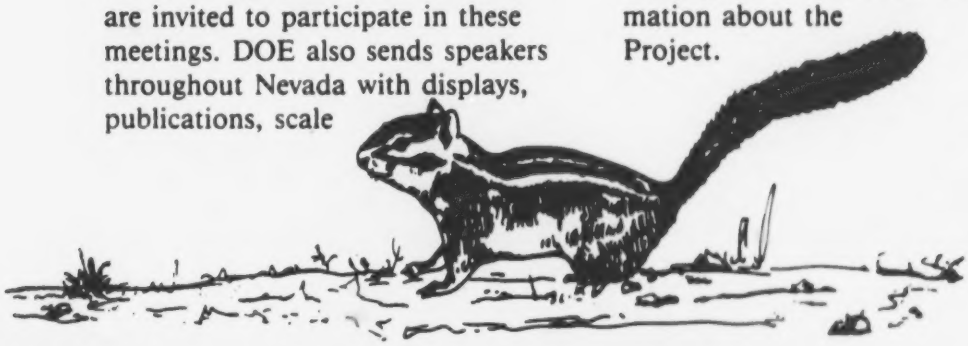
Three agencies have been created by the state of Nevada to conduct repository-related activities for the state:

- The Nevada Commission on Nuclear Projects is charged with advising the governor and the Nevada Legislature on nuclear waste matters and making recommendations on state policy.
- The Nevada Agency for Nuclear Projects/Nuclear Waste Project Office is responsible for all state oversight of the high-level nuclear waste program and for carrying out Nevada's responsibilities under the Nuclear Waste Policy Act. It produces technical reports, public information materials, and studies in geotechnical, environmental, socioeconomic, and transportation areas.
- The Nevada Legislature's Committee on High-Level Radioactive Waste is a seven-member oversight panel of Senate and Assembly members.

In addition, the Nevada Local Government Planning Group is an informal body of representatives from local governments and Indian tribes organized to keep local governments informed about repository issues organized in 1983. It is chaired by the Nevada Agency for Nuclear Projects.

DOE places high priority on communicating with the public

DOE places a high priority on communicating with Nevadans. DOE holds public meetings to tell citizens what is happening and to answer their questions. Several meetings are held each year in towns throughout the state. State and local officials are invited to participate in these meetings. DOE also sends speakers throughout Nevada with displays, publications, scale models, videos, and audiovisual materials. Two public information offices, in Las Vegas and in Beatty (about 28 kilometers or 18 miles from Yucca Mountain), are open daily. DOE also maintains a large mailing list to distribute information about the Project.



A repository is an enormous challenge

Scientists believe it is possible, using technology we have today, to design, construct, and operate a repository safely. What is challenging about this project is combining the work of different fields of science into systems which reflect complex interactions among different parts of the environment for thousands of years. This project requires experts who specialize in different fields of science to see how their findings interact with findings from other scientific fields. Once the experts have studied these interactions, they must make predictions based on these interactions.

For example, predicting water movement through rock is not enough. That prediction must consider possible changes in climate, and resulting effects on erosion and on the movement of water through rock, over thousands of years.

This project is also a significant challenge to the ability of people to work together to resolve a complex issue. We have the opportunity to play a part in making important decisions about energy and the environment, decisions that will affect and protect not only ourselves, but future generations.

Answers to some frequently asked questions

Q. ***What is monitored retrievable storage (MRS)?***

A. An MRS facility is an above-ground facility that would provide temporary, short-term storage for spent fuel. It would be regularly monitored. The facility would receive spent fuel from commercial reactors, store the fuel, and ultimately ship the fuel to a permanent repository.

The Amendments Act authorized DOE to site, construct, and operate an MRS facility, subject to certain conditions. The Nuclear Regulatory Commission (NRC) is responsible for licensing and regulating nuclear waste facilities, including an MRS. DOE would be required to apply for a license from the NRC. This application must include a safety analysis report, an environmental impact statement, information on MRS facility design and operation, a plan for closing the facility, and a plan for cleaning up radioactive contamination of the site and facilities. The licensing process includes opportunities for public review and comment. Federal law, the Nuclear Waste Policy Act, prohibits placing an MRS facility in a state where a permanent repository is located. No state has been selected as the site for a repository or an MRS.

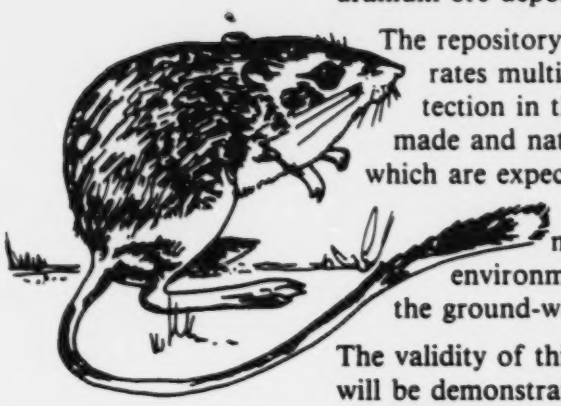
Q. ***Who pays for nuclear waste management?***

A. Customers who use nuclear power pay for the disposal of spent fuel. The federal government collects a fee of one mil (one-tenth of a cent) per kilowatt-hour of nuclear-generated electricity from utilities. This money goes into the Nuclear Waste Fund. In addition, the federal government will pay its share for disposal of defense high-level waste.

The Nuclear Waste Fund pays for all aspects of the U.S. nuclear waste management program. DOE, the state of Nevada, and local governments of communities that could be affected by the proposed repository receive money from the Nuclear Waste Fund through congressional appropriations. Money from federal income taxes are not used to support the program. The General Accounting Office, an arm of the U.S. Congress, oversees expenditures from the fund. Additionally, the Nuclear Waste Fund is audited annually by a public accounting firm.

Q. ***Could radioactive materials or gases get out of a repository?***

A. Most scientists believe the radioactive materials will escape eventually, but only in extremely small amounts over long periods of time. By that time, the radioactivity will have decayed to a level that will not be any more harmful than natural, underground, uranium-ore deposits.



The repository design incorporates multiple layers of protection in the form of man-made and natural barriers which are expected to isolate the radioactive materials from the environment, including the the ground-water table.

The validity of this design concept will be demonstrated by the DOE to the NRC in order for the DOE to obtain a license to operate the facility.

The man-made barriers are the first layer of protection. DOE must demonstrate that waste packages could substantially contain the radioactive spent fuel during the first 300 to 1,000 years. The solid waste will be sealed in metal corrosion-resistant or ceramic containers to keep any moisture from reaching the spent fuel. This is important because most scientists believe that the primary way radioactive material from a repository could be transported to the environment is by being moved by water.

Natural barriers form the subsequent layers of protection. Most scientists believe that when the waste containers are first placed in rock, the heat from the waste packages will dry any moisture present in the surrounding rock mass. After 1,000 years, repository engineering will still help prevent the movement of radioactive materials because an air gap around the package will help prevent water in surrounding rock from reaching and corroding the container. Should any radioactive material be dissolved and begin to move through the rock, it is believed that some of this material would stick to the "zeolites," or minerals, in the volcanic rock and this could slow their movement from a repository. In many parts of the country, the action of zeolites is used in the process that removes unwanted minerals from hard water. This is called water softening.

Q. ***Has high-level waste or its equivalent ever been geologically isolated?***

A. Experts often point to the example of a spontaneous nuclear chain reaction that occurred about 1.5 billion years ago in a rich uranium deposit in what is now Gabon, West Africa. This natural

chain reaction produced the same types of wastes as man-made reactors. Studies of the site show that most of the fission products and virtually all of the other elements including plutonium have moved less than a distance of 1.8 meters (six feet) from where they were formed 15 million centuries ago.

A more recent example occurred in the early-1980s when DOE scientists successfully placed and then retrieved spent fuel at Climax Mine, 427 meters (1,400 feet) beneath the Nevada Test Site. Radiation readings in the drift above the emplacement holes were below the natural radiation readings from the granite. The spent fuel was removed in 1983 and eventually shipped to the Idaho National Engineering Laboratory.

Q. ***What has been done to study volcanoes?***

A. At one time, active volcanoes existed in the region near Yucca Mountain. It is important to know whether there could be renewed volcanic activity and whether such activity could affect a repository.

Project scientists have been studying volcanism at Yucca Mountain for the past 10 years. Volcanism studies show that the last eruptions from two of seven volcanic centers located about 19 to 43 kilometers (12 to 27 miles) from Yucca Mountain may have occurred less than 10,000 years ago. Scientists think this does not affect the integrity of Yucca Mountain. They believe the potential for a volcano to erupt in the Yucca Mountain region is so small that it would not make the site unsuitable for a repository, but more studies are needed to prove or disprove their belief. Site studies will provide additional information on the record of volcanism at Yucca Mountain.

For volcanic centers in that area, the years since their last eruption range from the two already mentioned as being possibly less than 10,000 years to 3.7 million years.

Data gathered so far suggest that beneath the volcanoes near Yucca Mountain there is no evidence of a magma chamber (an underground pocket of rock and earth so hot it has melted to a liquid or paste). That makes the likelihood of a new volcano in the Yucca Mountain region extremely remote. The chance of a volcano directly affecting a repository in that area has been calculated as ranging from one in 10 million to one in 10 billion per year, but more studies are planned. The volcanoes in the Yucca Mountain region are 13-43 kilometers (8-27 miles) from the site being studied for a potential repository location.

Q. ***What has been done to study earthquakes and geologic faulting (major cracks and movement of the rock)?***

A. Project scientists have been studying existing faults and earthquakes in the region surrounding Yucca Mountain for more than 10 years. These studies will continue during site characterization and probably for years beyond that period.

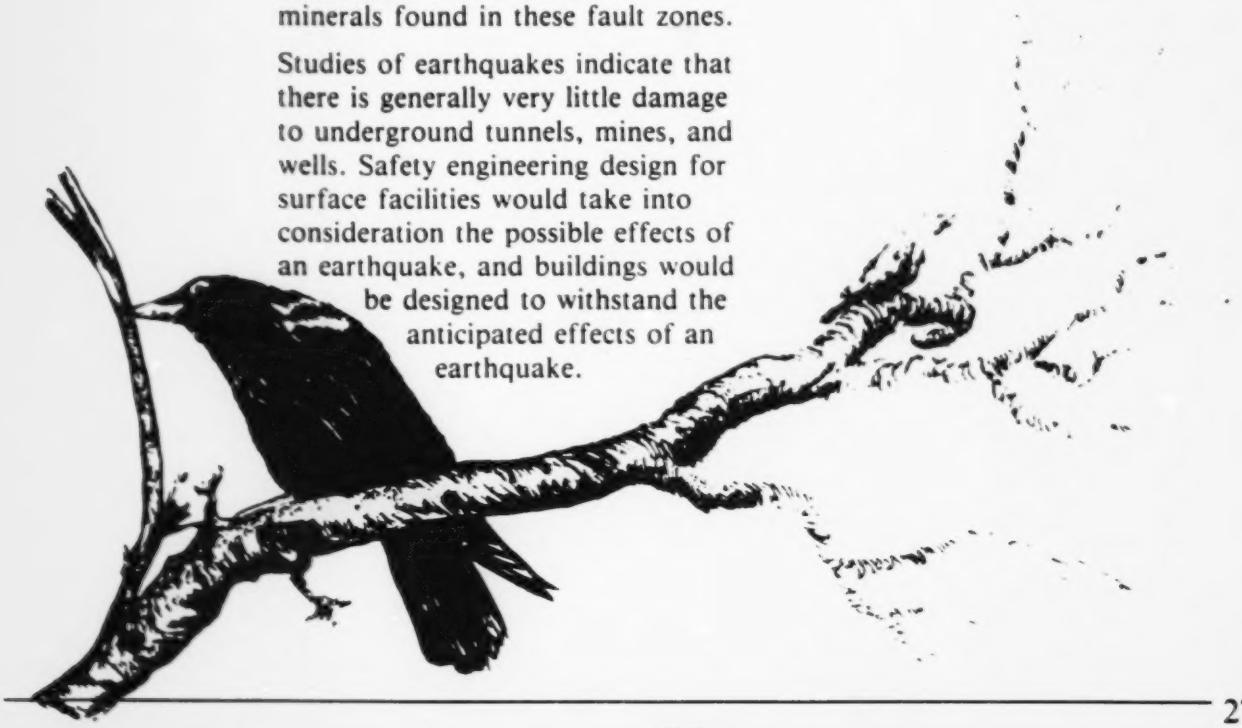
There are major trenching programs in which scientists have and will (once necessary permits are granted) continue to study fault movement during the past two million years. Information gained from these efforts will provide evidence of the history of past movements of faults. It will also provide information about how frequently the faults moved and how much they moved during each episode of movement. In addition, Project scientists will study minerals found in these fault zones.

Studies of earthquakes indicate that there is generally very little damage to underground tunnels, mines, and wells. Safety engineering design for surface facilities would take into consideration the possible effects of an earthquake, and buildings would be designed to withstand the anticipated effects of an earthquake.

Q. ***What about reprocessing the fuel?***

A. The chemical process by which uranium and plutonium are recovered from spent fuel is called "reprocessing." Commercial reprocessing of spent nuclear fuel is currently being done in several countries that use nuclear energy. The United States reprocesses military and defense spent fuel. Because reprocessing is more expensive than mining and processing uranium ore for fuel, private industry finds reprocessing uneconomical at this time.

When spent fuel is reprocessed, a highly radioactive liquid by-product remains. This can be turned into a solid, glass-like substance which then can be placed permanently in a repository.



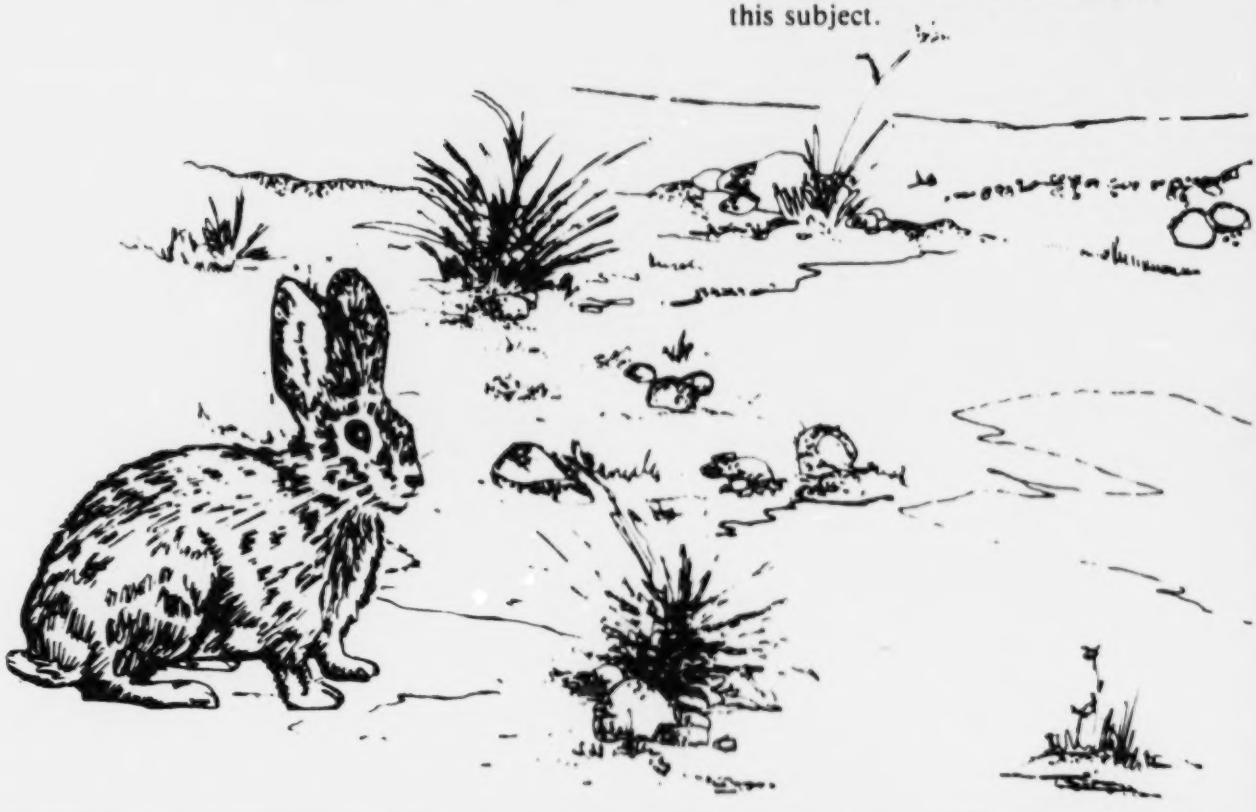
Q. ***If I am interested in learning more about this program and understanding the issues involved, what may I do?***

A. You can learn the basic facts and research the issues necessary to evaluate what is being said and written. The U.S. Department of Energy has a number of publications which are available to anyone requesting them. To receive them, write the Yucca Mountain Site Characterization Project office, Post Office Box 98608, Las Vegas, NV 89193-8608, or the Office of Civilian Radioactive Waste Management (OCRWM) Education and Information Division (RW-5). The OCRWM office address is 1000 Independence Avenue, S.W., Washington, D.C. 20585.

DOE also has an electronic bulletin board program called Infolink which has current program information, a publications catalogue and a publications ordering capability. For more information about using Infolink, please write to the OCRWM office at the aforementioned address.

The state of Nevada provides information to people requesting it by writing the Nevada Agency for Nuclear Projects/Nuclear Waste Project Office, Capitol Complex, Carson City, NV 89710. Other agencies officially involved in this program also have information they will furnish to people who request it.

The League of Women Voters has produced a book titled *The Nuclear Waste Primer, A Handbook for Citizens*, which is a resource on this subject.



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